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Description of the advertisement calls of nine species of *Fejervarya* Bolkay, 1915 and *Minervarya* Dubois, Ohler & Biju, 2001 from China, India and Nepal

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The advertisement calls of eight species of the genus *Fejervarya* and of *Minervarya sahyadris* (Dicroglossidae) are described in detail. This includes the advertisement calls of the holotypes of *F. pierrei*, *F. teraiensis* and *M. sahyadris*, as well as of a paratype of *F. nepalensis*. For each species, temporal and frequency parameters are provided, as well as an oscillogram and a spectrogram. The particular calls emitted before the advertisement call proper are discussed. The advertisement calls described herein are compared to previous call descriptions of the same species and some calls of unidentified *Fejervarya* species reported in literature are tentatively assigned to calls described herein. Calls of species which could occur in sympatry are compared to each other. The call of *M. sahyadris* is compared with the call of the recently described second species of the genus, *M. chilapata*.

INTRODUCTION

The genus *Fejervarya* is a taxonomically complex group of morphologically similar frogs comprising 32 currently recognized species distributed in Pakistan, India, Nepal, southern China, Indochina to the islands of the Sunda Shelf, and Japan and Papua New Guinea (FROST, 2010 [http://research.amnh.org/vz/herpetology/amphibia/amphibia/], 4 October, 2010).

Though the members of this genus inhabit open areas such as paddy fields and are usually quite common when present, their taxonomy is far from being fully resolved. Indeed this group of frogs is composed of morphologically very similar species, generally named *Fejervarya limnocharis*, which was so considered as a very largely distributed species. Even before molecular data (VEITH et al., 2001; KURABAYASHI et al., 2005; DJONG et al., 2007; KURAMOTO et al., 2007), advertisement calls turned out to be very useful in discriminating several new species of *Fejervarya* in the small country of Nepal, within the group that had been previously named *Rana limnocharis* (DUBOIS, 1975). The usefulness of advertisement



calls in discovery of new species or in the discrimination of sibling species is no longer debated (BOGERT & SENANAYAKE, 1966; LITTLEJOHN & OLDHAM, 1968; KURAMOTO, 1980; NARINS, 1983; MATSUI et al., 1986; SCHNEIDER & SINSCH, 1992; SCHNEIDER et al., 1993; NARINS et al., 1998). After the discovery of several species in Nepal (DUBOIS, 1975), ROY & ELEPFANDT (1993) recorded the call of three different *Fejervarya* species in a nearby region, northeastern India, thus confirming the existence of a species complex related to *Fejervarya limnocharis*.

Several field trips done by one of us (AD) from 1972 to 1992 permitted to record the calls of eight species of *Fejervarya* (*F. nepalensis*, *F. pierrei*, *F. rufescens*, *F. multistriata*, *F. syhadrensis*, *F.* sp. 1, *F. teraiensis* and *F.* sp. 2, among which the calls of the holotypes of *F. pierrei* and *F. teraiensis* and of one paratype of *F. nepalensis*), and of the holotype of *Minervarya sahyadris*. Four of these Fejervaryan calls have been briefly described previously (DUBOIS, 1975) and the call of *F. rufescens* used in this work has been recently described (KURAMOTO & DUBOIS, 2009). The call of *F. rufescens* had been previously described by KADADEVARU et al. (2000). Despite the importance of advertisement calls in species recognition and the abundance of the species of this genus in open and anthropized habitats, the calls of only a few additional *Fejervarya* species have been described until know: a species of Thailand referred to as *F. limnocharis* (HEYER, 1971), *F. cancrivora* from Kalimantan, Borneo (MATSUI, 1982), three unidentified *Fejervarya* species from northeastern India (ROY & ELEPFANDT, 1993), a species from southwestern India referred to as *F. limnocharis* (KANAMADI et al., 1995), a species from Bali, Indonesia tentatively referred to as *F. limnocharis* (MÁRQUEZ & EEKHOUT, 2006), *F. granosa*, *F. kudremukhensis* and *F. caperata* from southwestern India (KURAMOTO et al., 2007; the call of *F. kudremukhensis* has been described as *F.* cf. *keralensis* in KURAMOTO & JOSHY (2001) and the call referred to as *F. limnocharis* in the same paper could belong to *F. caperata*). The call of *M. sahyadris* has been described recently (KURAMOTO & JOSHY, 2001; KADADEVARU et al., 2002; KURAMOTO et al., 2007; in the two first references as *Limnonectes syhadrensis*, KURAMOTO et al., 2007).

The goals of this paper are (1) to describe the calls of the specimens recorded during the fieldtrips of AD, (2) to provide the call characteristics of the holotypes of *F. pierrei*, *F. teraiensis* and *M. sahyadris*, these data being particularly useful in integrative taxonomy of Amphibians (e.g. VIEITES et al., 2009), and (3) to compare them with the previously published call descriptions of *Fejervarya* species.

MATERIAL AND METHODS

The advertisement calls of nine species of Dicroglossidae of the genera *Fejervarya* and *Minervarya* were recorded in the field in India, Nepal and China from 1972 to 1992 by one of us (AD) (tab. 1, fig. 1–2).

Recordings were made using either an Uher Report 4000 or a Sony TCDM-5 tape recorders with two microphones LEM, and Scotch magnetic 215 and TDK SA-X90 tapes. Oscillograms and spectrograms were prepared with the Canary 1.2.4 software from the Cornell Laboratory of Ornithology (CHARIF et al., 1995). The sampling rate used to convert the signals to digital format was 22.254 Hz with a 16-bit precision. A filter bandwidth of

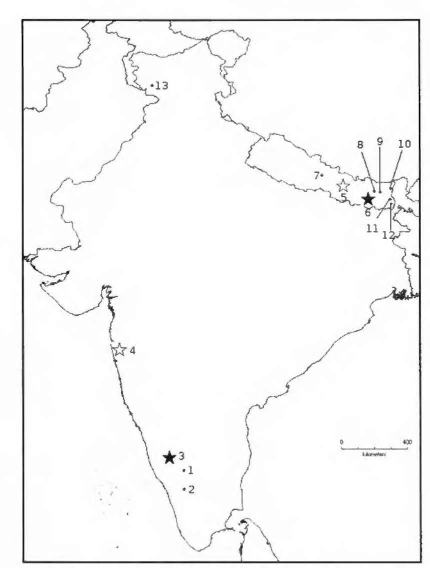


Fig. 1. – Recording localities and type localities of the *Fejervarya* and *Minervarya* species recorded in India and Nepal. Black stars represent type localities where advertisement calls have been recorded, white stars represent type localities. 1: Srirangapatna, recording site of *Fejervarya* sp. 1; 2: Udhagamandalam, recording site of *Fejervarya* sp. 2; 3: Gundia, type locality and recording site of *Fejervarya rufescens* and *Minervarya sahyadris*; 4: Poona district, Bombay Presidency, type locality of *Fejervarya syhadrensis*; 5: Godavari, type locality of *Fejervarya nepalensis*; 6: Birtamode, type locality of *Fejervarya pierrei* and *Fejervarya teraiensis* and recording site of *Fejervarya pierrei*, *F. syhadrensis* and *F. teraiensis*; 7: Kaneagats, recording site of *Fejervarya syhadrensis*; 8: Lumkua, recording site of *Fejervarya syhadrensis*; 9: Sitda Pokhari, recording site of *Fejervarya nepalensis*; 10: Kunga, recording site of *Fejervarya nepalensis*; 11: Ilam, recording site of *Fejervarya teraiensis*; 12: Sanichare, recording site of *Fejervarya teraiensis*; 13: Patnitop, Jammu & Kashmir, north India, recording sites of several *F. syhadrensis* displaying the same temporal and frequency characteristics as the conspecific populations described here.

Table 1. – List of the species studied with information on the place and date of recording. Air T°: air temperature.

Species	Inventory number	Sound number	Country	Date (hours)	Locality	Coordinates	Altitude	Air T°
Fejervarya sp. 1	Lost (field number 7489.D)	8930	India	18/VII/1984 (21h00–01h20)	Srirangapatna	12.4136°N, 76.7042°E	740–800 m	No data
	Lost (field number 7559.D)	8931–8932	India	18/VII/1984 (21h00–01h20)	Srirangapatna	12.4136°N, 76.7042°E	740–800 m	No data
Fejervarya rufescens	(1)	8933	India	25/VII/1984 (20h30–00h15)	Gundia, Kempholey forest	13.0833°N, 76.1167°E	200–220 m	No data
	(1)	8934	India	25/VII/1984 (20h30–00h15)	Gundia, Kempholey forest	13.0833°N, 76.1167°E	200–220 m	No data
Fejervarya sp. 2	(2)	8935	India	13/VII/1984 (22h10–23h00)	Udhagamandalam	11.4°N, 76.7042°E	2200–2210 m	No data
Minervarya sahyadris	2000.3031 **holotype**	8936–8938	India	25/VII/1984	Gundia, Kempholey forest	13.0833°N, 76.1167°E	200–220 m	No data
	2000.3033 **paratype**	8939	India	25/VII/1984	Gundia, Kempholey forest	13.0833°N, 76.1167°E	200–220 m	No data
Fejervarya nepalensis	1975.1628 **paratype**	8940	Nepal	9/V/1973 (19h10–22h45)	Kunga	About 27.5°N, 87.95°E	1580 m	21.0 °C
	1975.1676 **paratype**	8941	Nepal	12/VII/1973	Sitda Pokhari	27.32°N, 87.38°E	1530–1550 m	No data
Fejervarya pierrei	1975.1680 **holotype**	8942	Nepal	21/V/1973 (20h15–01h15)	Birtamode	About 26.9167°N, 86.8°E	200 m	24.0 °C
	1975.1706 **paratype**	8943	Nepal	22/V/1973 (19h45–23h10)	Birtamode	About 26.9167°N, 86.8°E	200 m	No data
Fejervarya syhadrensis	1975.1679	8944	Nepal	22/V/1973 (19h45–23h10)	Birtamode	About 26.9167°N, 86.8°E	200 m	No data
	1995.2534	8945–8946	Nepal	6/VII/1973 (20h20–24h00)	Lumkua	27.37°N, 87.05°E	890 m	No data
	1978.1751 (3)	8947	Nepal	8/IX/1972 (20h30)	Kaneagats	About 28.2°N, 84.2°E	850 m	22.7 °C
Fejervarya teraiensis	1975.1763 **holotype**	8948	Nepal	21/V/1973 (20h15–01h15)	Birtamode	About 26.9167°N, 86.8°E	200 m	24.0 °C
	1976.1147 **paratype**	8949	Nepal	29/IV/1973	Ilam	26.9167°N, 87.9167°E	1180–1210 m	24–26 °C
	(4)	8950	Nepal	22/IV/1973 (20h00–24h00)	Sanichare	26.68°N, 87.98°E	250 m	21.5–32.5 °C
Fejervarya multistriata	Lost (field number T.2062)	8951	China	19/VII/1992 (21h55)	Tunxi, Anhui Province	29.7114°N, 118.3125°E	125 m	27.3 °C

(1) 1984.2346, 1984.2348–2350 and 1984.2356; (2) 7426.D, 7429.D, 7454.D, 7499.D, V3 and V6; (3) a single calling male was caught but not necessarily the recorded one; (4) 1976.1128–1130, 1976.1132–1135.



Fig. 2. – Recording locality and type locality of *Fejervarya multistriata* from China. Black star represents the type locality (Lantau Island, Hong Kong), the black dot represents the site where the advertisement call has been recorded (Tunxi).

349.70 Hz and frame length of 512 points were used for both spectrogram and spectrum analyses.

A call is defined as a series of notes emitted consecutively and separated from another series of notes by a much longer interval than the interval separating two consecutive notes. In the case of *Fejervarya* species a call lasts from about ten seconds to several minutes, with the exception of *F. rufescens* for which a call is composed of only a long note. These long calling periods are named "calling bouts" hereafter. A note is an individual unit of sound composed of impulsions called pulses. A pulse is an energetic impulse. In the case of *Fejervarya* species, a note is composed of a series of pulses. The frequency bands are the different components visible on the spectrogram, the lowest being the fundamental, and the other the different harmonics. The band with the greatest emphasis is defined as the dominant frequency.

The following temporal parameters were scored from oscillograms: duration of the call (dc) and intercall duration (the silence interval between two consecutive calls, dic), duration of the notes (dn) and internote duration (the interval of silence between two consecutive notes, din), number of notes per call (nn) and note rate (the number of notes per second, nns), duration of pulses (dp), number of pulses per note (np), interpulse duration (dip) and pulse rate (number of pulses per second, nps). Frequency measurements were scored from the spectrum of a few notes within the signal and given as the mean of the frequency values of these notes for the same frequency band. The visible frequency bands are noted f1b to f3b from the fundamental frequency to the highest harmonic.

Most of the samples treated in this study are entire calls. However, the capacity of the software being reduced, we had to choose calls of short duration (lower to 5 seconds). Therefore the durations of calls (dn) are not typical values of the species.

All specimens are deposited in the herpetological collections of the Muséum national d'Histoire naturelle of Paris (MNHN); see tab. 1 for details. The calls described herein are deposited in the Fonoteca Zoológica of the Museo National de Ciencias Naturales de Madrid (FZ collection numbers 8930–8951). A sample for each species is available in the web checklist of Frog Calls of the World, at <www.FonoZoo.com>.

All males of this genus have the same calling site. They call from the ground or from grasses on the ground, very close to the water edge but never in the water itself, only sometimes with the rear part of the body slightly in the water. Even if the males are within a flooded area, they call sitting on emergent mounds, or perched on emergent plants as in the case of *F. nepalensis* from Sitda Pokhari. So as all recorded males were outside water, only air temperature is given when available (tab. 1). All the *Fejervarya* species call in choruses and as such are heard from several dozen of meters by a human listener.

It is not possible to provide a collection number to each animal because some individuals could not be caught or were lost as a result of logistic problems. The calling male of *F. rufescens* was lost during storing before transportation. In these cases, the snout-vent length given was obtained by the mean of the snout-vent length of males caught in the population of the calling male. The collection numbers of individuals taken into consideration for calculation of the means are the following (tab. 1):

(1) *Fejervarya rufescens*: 1984.2346, 1984.2348–2350 and 1984.2356.

(2) *Fejervarya* sp. 2: 7426.D, 7429.D, 7454.D, 7499.D, V3 and V6.

(3) A single calling male of *Fejervarya syhadrensis* has been caught but not necessarily the recorded one.

(4) *Fejervarya teraiensis*: 1976.1128–1130, 1976.1132–1135.

Observations

India

Fejervarya sp. 1

The three calls studied here are entire sequences. The call of *Fejervarya* sp. 1 (fig. 3a, tab. 2) is composed of a series of 9 to 16 multi-pulsed notes and lasts 3.24 s in average. The duration of notes averages 0.11 s and the intervals between them 0.15 s. The notes are emitted at a rate of 4.2 per second. Each note (fig. 3b) consists of about 20 pulses of very short duration (about 5 ms) and lacks pulse intervals. The pulses are emitted at a rate of 181 pulses per second on average. The duration of notes increases during the call. So, the number of pulses increases with the duration of notes (from 14 to 28 for the largest range). The notes have

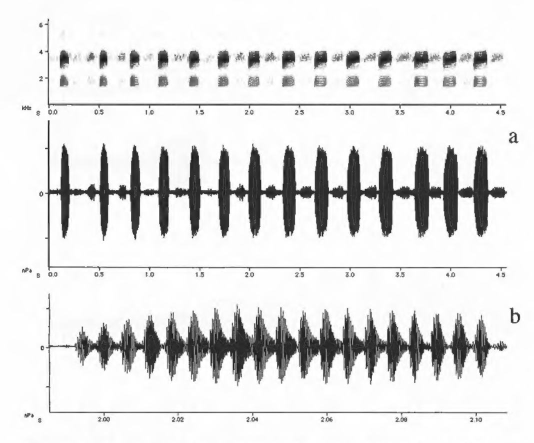


Fig. 3. – (a) Spectrogram and oscillogram of an advertisement call of *Fejervarya* sp. 1 (field number D.7489) and (b) detailed oscillogram of the 7th note.

a very fast (abrupt) rise time and decrease just as fast. The amplitude of pulses increases abruptly at the beginning of the note and decreases slowly at the end.

The fundamental frequency lies at about 1724 Hz. The dominant frequency corresponds to the second frequency band (the first harmonic) and lies at about 3417.6 Hz. A slight upwards frequency modulation of the dominant frequency band is observed at the beginning of notes.

Fejervarya rufescens (Jerdon, 1854)

The advertisement call of *Fejervarya rufescens* (fig. 4a, tab. 2) is a long noisy note with increasing intensity. In this case, the call is synonym of note. The duration of the call is relatively short with a mean of 0.349 second, separated by a silence of 1.59 s in average and emitted at a rate of 0.74 notes per second. The calls are formed of about 60 pulses (fig. 4b). The amplitude of pulses increases greatly from the beginning of the note until the last pulses, the amplitude of which decreases abruptly. The pulses are emitted at a high rate, without silence between them.

Table 2. – Characteristics of the advertisement calls of several *Fejervarya* species and *Minervarya sahyadris* from India and of *Fejervarya multistriata* from China. MNHN: inventory number of MNHN; svl: snout-vent length of the recorded male in mm (when a mean is given, it refers to the mean of all caught males in the population of the recorded male; see *Material and methods* section); dc: duration of the call from first to last note; dic: duration of the interval between two consecutive calls; dn: duration of notes; din: duration of the interval between two consecutive notes; nn: number of notes per call; nns: number of notes per second; dp: duration of pulses; np: number of pulses per note; nps: number of pulses per second; f*i*b: frequency of the band *i*. Time measurements expressed in seconds; frequency in Hz. Values are given as: mean ± standard deviation, minimum-maximum, (number of measurements).

Species	MNHN	svl	dc	dic	dn	din	nn	nns	dp	np	nps	f1b	f2b	f3b
Fejervarya sp. 1	7489.D	-	4.28	-	0.111 ± 20.7 0.080–0.134 (14)	0.207 ± 36.5 0.154–0.305 (13)	14	3.3	about 0.006	18.7 ± 3.2 14–22 (14)	169.5 ± 3.7 164.0-175.9 (14)	1807	3448	-
Fejervarya sp. 1	7559.D	-	2.72 1.86–3.58 (2)	-	0.110 ± 19.6 0.073–0.143 (25)	0.116 ± 48.4 0.083–0.297 (23)	12.5 9–16 (2)	4.7 4.5–4.8 (2)	about 0.005	20.7 ± 4.0 14–28 (25)	188.7 ± 8.1 169.8–201.5 (25)	1535–1802	3017–3788	
Fejervarya rufescens		33.1 ± 1.36 32.3–35.5 (5)	0.349 ± 0.72 0.267–0.422 (4)	1.59 ± 0.46 (2)	-	-	1 1–1 (4)	0.7 0.7–0.8 (2)	-	about 60	-	1117–1420	2410–3027	-
Fejervarya sp. 2		32.8 ± 1.68 30.5–35.3 (6)	1.57	-	0.095 ± 0.024 0.068–0.125 (4)	0.398 ± 0.024 0.371–0.417 (3)	4	2.5	0.009	5.25 ± 0.96 4–6 (4)	55.2	818.7	1068.5	-
Minervarya sahyadris	2000.3031	19.1	0.776 ± 0.103 0.668–0.872 (3)	-	0.034 ± 0.006 0.023–0.047 (24)	0.071 ± 0.055 0.026–0.245 (21)	8 ± 1 7–9 (3)	10.4 ± 1.1 9.2–11.4 (3)	0.004–0.007	6.63 ± 1.41 5–10 (24)	202.5 ± 30.1 152.4–256.2 (3)	3625–3700	-	-
Minervarya sahyadris	2000.3033	18.0	0.998	-	0.032 ± 0.005 0.027–0.044 (10)	0.076 ± 0.049 0.050–0.203 (9)	10	10.0	about 0.004	7.00 ± 1.15 6–9 (10)	218.5	3694.4	-	-
Fejervarya multistriata	T.2062	37.3	0.381 0.367–0.394 (2)	1.53	0.080 ± 0.011 0.070–0.094 (4)	0.210 0.191–0.229 (2)	2 2–2 (2)	5.3 5.1–5.5 (2)	0.010	7.25 ± 0.5 7–8 (4)	91.1 ± 7.9 83.9–99.6 (4)	1371	3017	4007

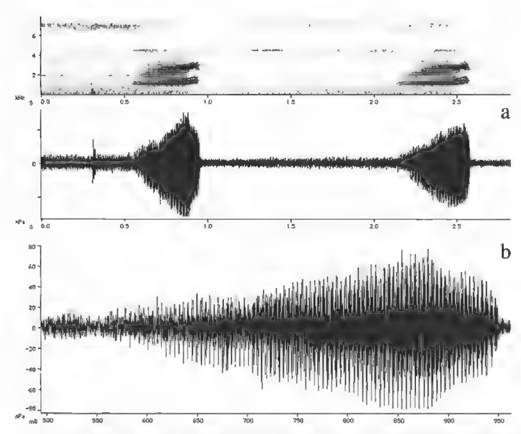


Fig. 4. (a) Spectrogram and oscillogram of two advertisement calls of *Fejervarya rufescens* and (b) detailed oscillogram of the 1st call

Two frequency bands are present, the fundamental lying at 1117–1420 Hz whereas the dominant lies at 2410–3027 Hz. The frequency of the note increases during its emission, which is especially visible in the dominant frequency. This change of frequency within the note is coupled with an intensity modulation to the note (increase in this case)

Fejervarya sp. 2

The call of *Fejervarya* sp. 2 (fig 5a, tab. 2) is composed of short multi-pulsed notes. The notes last 0.095 s in average, are separated by silences of 0.398 s in average and are emitted at a rate of 2 5 notes per second. The maximum amplitude of the note is reached in the middle of the note. The notes are composed of two or three groups of two pulses (fig. 5b). These groups are separated by durations comprised between 0 012 and 0 047 second. There are no silences inside the groups. Despite the variation of the duration of notes and of the number of pulse groups, the call appears homogenous to the listener.

Two frequency bands are present, the fundamental lying at about 820 Hz and the dominant at about 1070 Hz.

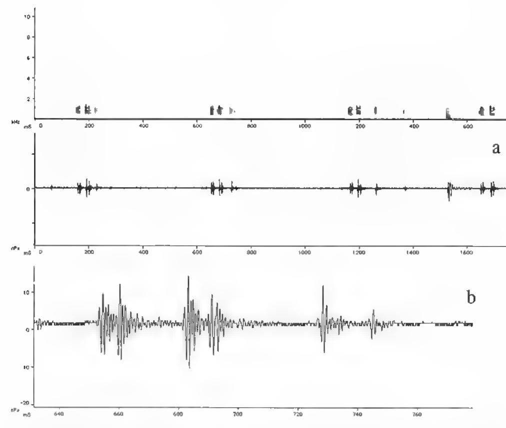


Fig. 5. – (a) Spectrogram and oscillogram of an advertisement call of *Fejervarya* sp. 2 and (b) detailed oscillogram of the 2nd note.

The sample described here is only a short part of a calling bout. It does not represent an entire call.

Minervarya sahyadris Dubois, Ohler & Biju, 2001

The specimen recorded is the holotype of *Minervarya sahyadris*.

The call of *M. sahyadris* (fig. 6a, tab. 2) lasts less than 1 second and is composed of a series of 7-10 multi-pulsed notes. The notes which last in average 0.033 s are emitted very quickly (about 10 notes per second) and are high-pitched. The duration of internote intervals is relatively short (0.073 s in average). The first note is always longer, with a greater amplitude, composed of more pulses, and separated from the second one (mean din = 0.190 s) by a longer interval than all the following notes between them. The second note, though of same amplitude and duration as the following ones, is frequently separated from the third one by a slightly longer silence than those between the following notes (mean din = 0.096 s). The mean duration of the internote intervals between the following notes is 0.048 s. Consequently, the

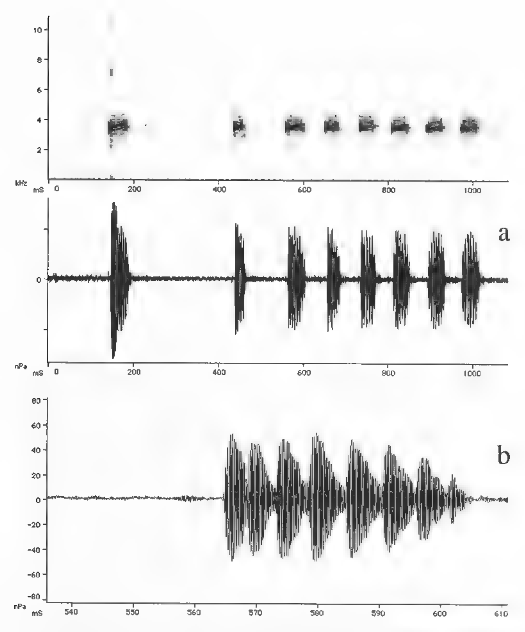


Fig 6 (a) Spectrogram and oscillogram of an advertisement call of the holotype of *Minervarya sahyadris* (MNHN 2000.3031) and (b) detailed oscillogram of the 3rd note.

Table 3. Characteristics of the advertisement calls of four species of *Fejervarya* from Nepal. For legends, see Table 2. dip: interpulse duration.

Species	MNHN	svl	dc	dic	dn	Din	nn	nns	dp	dip	np	nps	f1b	f2b	f3b
Fejervarya nepalensis	1975.1628	27.4	3.76	-	0.385 ± 0.013 0.370–0.406 (5)	0.460 ± 0.036 0.430–0.505 (4)	5	1.3	0.003	0.003	58.2 ± 2.8 56–63 (5)	151.0 ± 2.8 148.0–155.2 (5)	1711.3	2834.3	4303.6
Fejervarya nepalensis	1975.16[illegible]6	28.9	4.50		0.[illegible]73 ± 0.005 0.164–0.181 (10)	0.306 ± 0.060 0.228–0.390 (9)	10	2.2	0.007		2[illegible].4 ± 0.5 21–22 (10)	124.0 ± 4.3 117.5–131.5 ([illegible]0)	[illegible]828.3	3631.3	-
Fejervarya pierrei	1975.1680	29.5	2.96		0.259 ± 0.0[illegible]0 0.247–0.275 (9)	0.078 ± 0.005 0.072–0.085 (8)	9	3.0	0.004	0.001	19.7 ± 1.9 17–23 (9)	76.0	1880.6	4212.3	8581.3
Fejervarya pierrei	1975.1706	30.0	3.53	-	0.257 ± 0.027 0.221–0.302 (10)	0.[illegible]06 ± 0.064 0.072–0.274 (9)	10	2.8	0.003	0.001	18.6 ± 2.0 16–22 (10)	72.4	[illegible]717.6	4114.3	
Fejervarya syhadrensis	1975.1679	27.1	2.86	-	0.061 ± 0.007 0.054–0.081 (26)	0.051 ± 0.007 0.039–0.067 (25)	26	9.1	0.005	-	11.9 ± 1.4 11–15 (26)	194.7 ± 6.0 180.4–201.7 (26)	1548	3467.7	-
Fejervarya syhadrensis	1995.2534	29.5	2.94 2.91–2.97 (2)	-	0.054 ± 0.004 0.045–0.066 (54)	0.059 ± 0.041 0.0[illegible]5–0.226 (52)	27 (2)	9.[illegible] 9.1–9.3 (2)	0.005	-	10.7 ± 0.8 9–13 (54)	99.7 ± 8.77 183.6–219.1 (28)	1638	3340.5	5346.5
Fejervarya syhadrensis	1978.1751	28.6	1.41	-	0.052 ± 0.004 0.046–0.058 (13)	0.061 ± 0.021 0.046–0.125 (12)	13	9.2	0.004	-	11.5 ± 0.5 11–12 (13)	219.7	1709.5	3600.5	5622.7
Fejervarya teraiensis	1975.1763	41.6	2.53	-	0.071 ± 0.005 0.066–0.079 (9)	0.232 ± 0.097 0.158–0.438 (8)	9	3.6	about 0.014	-	5.3 ± 0.5 5–6 (9)	74.8	1117	2439	3879.3
Fejervarya teraiensis	1976.1147	35.1	1.07 1.06–1.09 (2)	0.765	0.103 ± 0.021 0.64–0.119 (6)	0.372 ± 0.173 0.179–0.557 (4)	3	2.8	about 0.013	-	7.2 ± 1.3 5–8 (6)	69.4	1117	2454	3840
Fejervarya teraiensis	-	40.6 ± 4.12 31.9–44.0 (7)	1.28 0.927–1.63 (2)	[illegible].37	0.081 0.009 0.067–0.094 (8)	0.317 ± 0.071 0.189–0.374 (6)	4 3–5 ([illegible])	3.[illegible] 3.1–3.2 ([illegible])	about 0.014	-	5.6 ± 0.5 5–6 (8)	69.6	1038	2[illegible]16	27 6.6

emission rate of the notes increases during the call The notes are composed of 5 to 10 very densely arranged pulses lasting from 4 to 7 ms and without silence between them, and emitted at a rate of 200 pulses per second (fig. 6b) The largest pulse is usually the first or the second of each note, then their amplitude decreases. So the maximum amplitude of the note is reached very quickly after what the amplitude of the note decreases more slowly. The structure of the pulses resembles that of the note.

Only the fundamental frequency, which is also the dominant frequency, is visible It lies at about 3650 Hz.

NEPAL

Fejervarya nepalensis (Dubois, 1975)

Contrary to the other species, *F nepalensis* (fig 7) is a forest species. During day time, it is often found on the forest floor. It is also found near ponds at the edge of forests.

The advertisement call of *Fejervarya nepalensis* is a sequence of long multi-pulsed notes. It is remarkable, however that this is the only characteristic shared by the calls of the two specimens recorded from two different localities. The recording person noticed differences between the two frogs in his fieldnotes. As these two calls differ in all respects, they are described independently.

The call of *F nepalensis* from Kunga (paratype), which is an entire call sequence, is composed of long notes (0.385 s in average) separated by long intervals (0.460 s in average)



Fig 7. A female of *Fejervarya nepalensis* from Bibare Bazar, Nepal, the 13[th] July 1973

and emitted at a slow rate of 1.3 note/s (fig. 8a, tab. 3). The duration of the notes and of the intervals between notes are the largest among the species described herein whereas the note rate is the slowest of all species. The notes are composed of a large number of pulses (56–63) of 3 ms of duration with a group of greatest amplitude at the beginning of each note (fig. 8b). Three frequency bands are visible, the fundamental frequency lying at about 1710 Hz, the dominant at about 2830 Hz and the third band of energy at about 4300 Hz. The dominant frequency shows an upwards frequency modulation within each note.

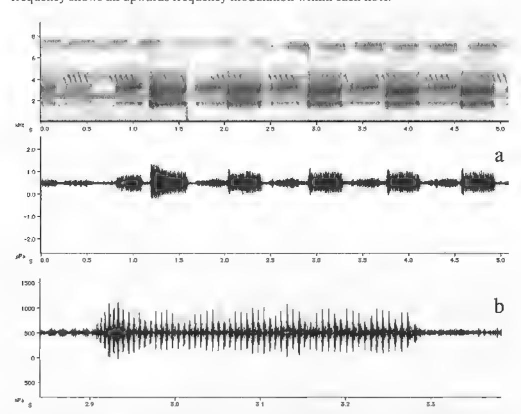


Fig. 8. (a) Spectrogram and oscillogram of an advertisement call of one paratype of *Fejervarya nepalensis* (MNHN 1975.1628) from Kunga and (b) detailed oscillogram of the 3rd note. The notes of a second calling male are visible between the notes of the described call.

The call of *F. nepalensis* from Sitda Pokhari (paratype) is composed of shorter notes of 0.173 s in average separated by intervals of 0.300 s in average and emitted at a rate of 2.2 notes/s (fig. 9a, tab. 3). This is only a part of call which can last until two minutes. The notes are composed of 21–22 pulses of 7 ms of duration arranged in three groups per note, the pulses of each group increasing then decreasing in amplitude (fig. 9b). Two frequency bands are visible, the first one at about 1830 Hz and the second at about 3630 Hz. The dominant frequency is the fundamental.

In summary, the calls of these two specimens differ in the duration of the notes, the duration of the intervals between them, the number of pulses per note, and the pulse and note

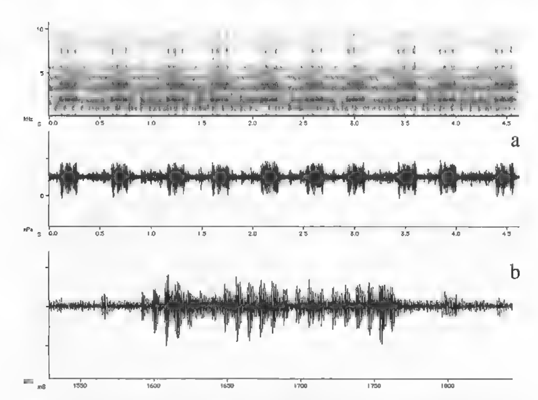


Fig 9. – (a) Spectrogram and oscillogram of an advertisement call of one paratype of *Fejervarya nepalensis* (MNHN 1975 1676) from Sidda Pokhari and (b) detailed oscillogram of the 4[th] note.

rate. The frequency bands are higher in individual from Kunga and the dominant frequency is not represented by the same harmonic in the two individuals. These two calls probably belong to two different species.

Fejervarya pierrei (Dubois, 1975) (fig. 10)

One of the calls described herein was emitted by the holotype (MNHN 1975.1628, fig. 11).

The call of *Fejervarya pierrei* (fig. 12a, tab. 3) is a series of long multi-pulsed notes lasting 0.258 s in average. The durations of internote intervals are short, 0.092 s in average, in comparison to the calls of the other *Fejervarya* species. However, due to the relatively important duration of notes, the note rate (2.9 notes per second) is not affected. These notes are composed of five or six groups of three to five large pulses separated by seven or eight small pulses (fig. 12b) giving the call a trill-like sound. The first or the second group of pulses has the greatest amplitude which decreases slightly in the subsequent pulse groups.

Two or three frequency bands are present, the fundamental lying at about 1800 Hz, the second and dominant frequency is about 4200 Hz and the third one, when present, at about 8600 Hz.

This call sounds like a cricket song.

Fejervarya syhadrensis (Annandale, 1919)

The calls analysed herein (from Birtamode, Lumkua and Kaneagats, Nepal) are whole sequences but chosen among the shortest for the convenience of the software limitations (the maximum length capacity of the software is 14 s). The call of *Fejervarya syhadrensis* (fig. 13 and 14a, tab. 3) is a fast series of short multi-pulsed notes (0.055 s on average). The durations of internote intervals are very reduced (din = 0.057 s, n = 89). This is the highest call rate among calls studied here (9.17 notes per second on average) due to both short note and internote intervals. Each note is composed of 9–15 pulses (about 0.005 s) without interpulse



Fig 10. – A calling male of *Fejervarya pierrei* from Belbari, Nepal, the 23rd May 1973



Fig 11 – The holotype of *Fejervarya pierrei* (MNHN 1975.1680) from Birtamode, the 21st May 1973

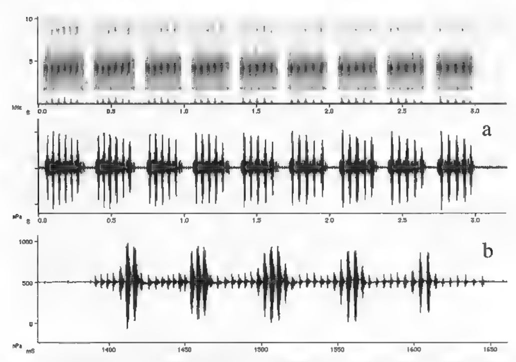


Fig. 12. – (a) Spectrogram and oscillogram of an advertisement call of the holotype of *Fejervarya pierrei* (MNHN 1975.1680) and (b) detailed oscillogram of the 5th note.

interval (fig 14b). The amplitude of pulses increases slightly at the beginning of call and decreases in the same way at the end. The last pulse is always shorter than the previous ones.

These calls typically have one note then two groups of two notes before a rapid and continuous emission of notes. Although the duration and the number of pulses of any note in the call is noticeably the same, the silence duration between each of these groups is three to four times bigger (0.171 ± 0.037, $n = 6$) than the silences within both the groups of two notes and the following succession of notes (0.048 ± 0.007, $n = 83$).

The fundamental frequency is at about 1634 Hz and the dominant frequency peak (the first harmonic) lies at about 3440 Hz The spectrogram is characterized by a wide range with up to six harmonic bands.

Fejervarya teraiensis (Dubois, 1984) (fig. 15)

The call of the specimen MNHN 1975.1763, which is the holotype of *F teraiensis* (fig. 16), described here, is only a small sample of a calling bout lasting about 1.5 minute. The calls of the two other specimens analysed herein are whole calls.

The call of *Fejervarya teraiensis* (fig. 17a, tab. 3) is a continuous series of short multi-pulsed notes. The duration of notes averages 0 085 s and the intervals between them, 0.31 s. The duration of the intervals between the notes is highly variable, even within a call (range 0.158–0 557 s, SD = 0.118, $n = 18$). So the notes are emitted at an irregular rate. The note rate

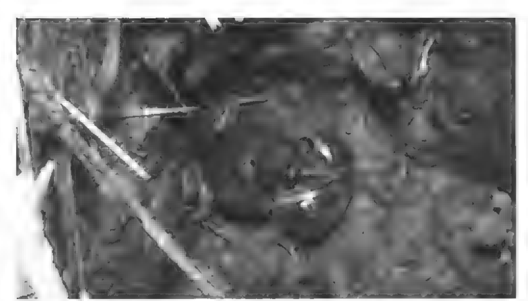


Fig. 13. - A calling male of *Fejervarya syhadrensis* from Burimorang, Nepal, the 24th July 1973.

Fig. 14. - (a) Spectrogram and oscillogram of an advertisement call of *Fejervarya syhadrensis* (MNHN 1995.2534) from Lumkua and (b) detailed oscillogram of the 16th note.

is about 3.2 notes per second. Each note consists of 5 8 large pulses (fig 17b) without interpulse intervals (dp = 0.014 s). The amplitude of the note increases quickly (the second pulse is the largest) and decreases more slowly.

The dominant frequency is about 2450 Hz for the two first calls and 1040 Hz for the third. We can notice here a change in the dominant frequency: the dominant frequency is equal to f2b for the two first calls and f1b for the last one.

The spectrogram shows a wide frequency range with up to seven harmonic bands.



Fig 15 A male paratype of *Fejervarya teraiensis* (MNHN 1975 1764) from Burimorang, Nepal, the 27th July 1973.



Fig. 16 The holotype of *Fejervarya teraiensis* (MNHN 1975.1763) from Birtamode, the 21st May 1973

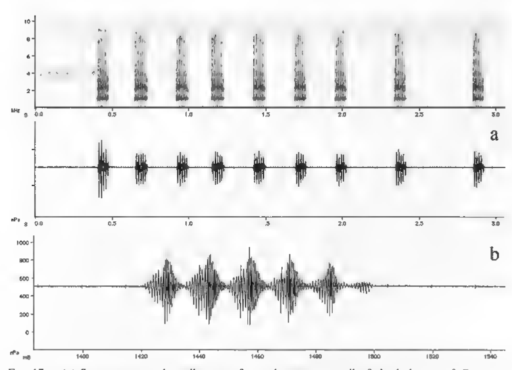


Fig 17 – (a) Spectrogram and oscillogram of an advertisement call of the holotype of *Fejervarya teraiensis* (MNHN 1975 1763) and (b) detailed oscillogram of the 5th note.

Table 4 Comparison of the frequency ranges of each frequency band among the four species of *Fejervarya* recorded from Nepal and the three species recorded from southwestern India.

	Species recorded from Nepal				Species recorded from southwestern India		
	F. teraiensis	*F. syhadrensis*	*F. nepalensis*	*F. pierrei*	*Fejervarya* sp. 2	*F. rufescens*	*Fejervarya* sp. 1
f1b	1.0–1.1	1.5–1.7	1.7–1.8	1.7–1.8	0.8	1.1–1.4	1.5–1.8
f2b	2.1–2.4	3.2–3.6	2.8–3.6	4.1–4.2	1.0	2.4–3.0	3.0–3.8
f3b	2.7–3.9	5.3–5.6	4.3	8.6	–		-

China

Fejervarya multistriata (Hallowell, 1861)

The call of *Fejervarya multistriata* (fig. 18a, tab. 2) is a short call (0.380 s) composed of groups of two multi-pulsed notes. These are only a few notes emitted before a longer call. These two groups of two notes are separated by an interval of 1.53 s. The duration of notes averages 0.08 s and the intervals between them, 0.21 s. The note repetition rate is relatively high (5.26 notes per second). Each note consists of seven or eight large pulses (10–12 ms) which have a decreasing amplitude throughout the note (fig. 18b). There is no silence interval between two consecutive pulses.

The dominant frequency is 1371 Hz. This is the only case where the dominant frequency is equal to the fundamental among the *Fejervarya* species studied here (except for *F. nepalensis*

from Sitda Pokhari). The frequency of the first pulse of each note is higher than the second resulting in frequency modulation.

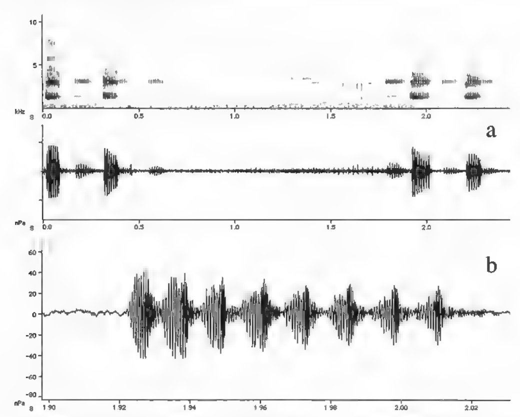


Fig. 18. (a) Spectrogram and oscillogram of an advertisement call of *Fejervarya multistriata* (T.2062) and (b) detailed oscillogram of the 1st note of the second call The notes of a second calling male are visible between the notes of the described call.

DISCUSSION

The calls described herein are all, with the exception of *F. rufescens*, a long and regular succession of trilled notes. These calls can last more than one minute. The same structure has been reported for the calls of other species in northeastern and southwestern India (ROY & ELEPFANDT, 1993; KANAMADI et al., 1995; KURAMOTO et al., 2007).

The calls of *Fejervarya* species are often introduced by a few notes, often grouped by two. These notes are present before each advertisement call and in all calling males. These small calls sound like timid attempts of advertisement calls and are emitted until the group of calling males "feels at ease". Then, as soon as a male is "sufficiently reassured", it begins emitting the typical advertisement call, immediately followed by all the other males in its vicinity. If the frogs are "inhibited", these notes can be emitted for a long period (GROSJEAN & DUBOIS, pers. obs.) These notes emitted alone or in pairs with a longer internote duration

before and after the typical advertisement call were reported by DUBOIS (1975), who reported larger internote durations but larger note duration too unlike our results and interpreted these notes as territorial call. In the same paper, DUBOIS (1975) illustrated a territorial call of *F teraiensis* (under the name *F "limnocharis"*) which was much longer and structurally different from the notes of the advertisement call of this species. Furthermore, KANAMADI et al (1995) observed the territorial behaviour of a *Fejervarya* species and described the territorial call whose notes have a different structure from the notes of the advertisement call. The few tentative notes at the beginning of the calls reported here have, on the contrary, exactly the same structure and the same duration as the following notes of the advertisement call. For these reasons we do not consider these notes as the territorial call.

The advertisement calls of *F nepalensis*, *F pierrei*, *F syhadrensis* and *F teraiensis* were briefly described elsewhere (DUBOIS, 1975, 1976).

The call of the specimen of *F rufescens* studied here was described by KURAMOTO & DUBOIS (2009). The measurements of the call parameters reported by these authors and those described here are of course very similar except for the number of pulses which is reported to be 25 in average by KURAMOTO & DUBOIS (2009) and about 60 here (reflecting perhaps differences in detectability of the pulses). The advertisement call of this species has also been described previously from the Western Ghats (KADADEVARU et al , 2000) In this population the number of pulses was 49 in average The waveform of the call of *F. rufescens* shown by these authors was very similar to that of the present study. However, the temporal values of our sample are bigger than those of *F rufescens* from the Western Ghats. For instance the notes last 349 ms and contain 60 pulses in average in our samples vs 242 ms and 49 pulses, and the interval between each note lasts 1.6 s in our samples vs 0 556 s. KADADEVARU et al. (2000) reported five frequency bands whereas only two are visible in our specimens. The dominant frequency matches in the two samples 2400–3000 Hz in this study and 2500–3520 Hz reported by KADADEVARU et al (2000). These differences could be due to temperature differences (unfortunately, no data are available for our recording), geographic variation or different hormonal state.

ROY & ELEPFANDT (1993) described the call of three unidentified species of *Fejervarya* from northeastern India All the values of the temporal parameters (note duration, interval duration between notes and number of pulses) of the species referred to as *F. limnocharis* are higher than those of *F. nepalensis* from Kunga, the species from Nepal and northern India which exhibits the greatest temporal value. On the contrary, the dominant frequency is lower in "*F limnocharis*" than in *F nepalensis*. However, the general waveform of the notes of the two species resembles greatly. The species named sp 1 in the same paper fits the call parameters of our *F. teraiensis*, a species which also occur in this region whereas the call parameters of the species named sp. 2 have no equivalent in our sample.

The distribution of *F syhadrensis*, if actually this taxon is not a species complex, is large, spreading from eastern Pakistan to Bangladesh, northern India and Nepal and most probably to northeastern India. One of us (AD) identified and recorded a species close to *F. syhadrensis* reported here as *F* sp. 1. However, except for the frequency parameters and the high pulse rate, the two calls share no similarity and sound differently. KANAMADI et al. (1995) described the advertisement call of a seemingly undescribed *Fejervarya* species. The call parameters (both temporal and frequency) reported by these authors perfectly fit the measurements of our *F* sp 1 as does the structure of the note. These two populations are likely conspecific On the

other hand, AD recorded also the calls of several *F. syhadrensis* from a distant population, at Patnitop, Jammu & Kashmir, northern India (about 1000 km distance; fig. 1). The calls of these specimens (data not shown) are identical to those described here, confirming the conspecificity of the two populations as well as the wide range of this species.

Among the eight *Fejervarya* species whose calls are described herein, three have been recorded in southwestern India (*F.* sp. 1, *F. rufescens* and *F.* sp. 2), four in Nepal (*F. nepalensis*, *F. pierrei*, *F. syhadrensis* and *F. teraiensis*) and one in China. Although the four Nepalese species inhabit different zoogeographic areas, they can occur in syntopy, particularly *F. syhadrensis* which can be found together with any of the three other species (DUBOIS, 1975, fig. 1). Thus, their advertisement call could play an important role as a premating isolating mechanism. The fundamental frequencies of three out of the four species overlap (tab. 4). Only the frequency bands of *F. teraiensis* are clearly outside the range of the three other species. *Fejervarya nepalensis* and *F. pierrei* have the same range of values for the fundamental frequency, but the dominant frequency plays probably the most important role. However, ROY & ELEPFANT (1993) suggested that a marked different dominant frequency between individuals might be useful for interindividual recognition. *Fejervarya syhadrensis* and *F. nepalensis* from Sitda Pokhari present the same dominant frequency but the calls differ clearly by the length of notes, the longest notes of *F. syhadrensis* remaining always shorter than the shortest notes of *F. nepalensis*. *Fejervarya syhadrensis* which can be found in syntopy with the three other species possesses the most divergent call. It has the shortest note durations, the shortest intervals between notes and the fastest call (which is expressed by more notes, high note rate and high pulse rate).

Fejervarya rufescens, *F.* sp. 1 and *F.* sp. 2 were all described from southwestern India (Karnataka and Tamil Nadu States). So they could potentially be syntopic. Here again, the advertisement call could be an important premating isolating mechanism. The values of the first two frequency bands do not overlap (tab. 4). Furthermore, *F. rufescens* has a very different call relative to the two other southwestern India species. Its notes are the longest as well as the intervals between them (which last more than one second). Due to the length of the notes, the note rate is particularly slow and the number of pulses high. The call of *F.* sp. 2 is remarkable by its notes containing a low number of pulses.

The advertisement call of *Minervarya sahyadris* described herein is of importance as it is the call of the holotype. The type locality is near the village of Gundia, Kempholey forest, Hassan District, Karnataka, India (13.0833°N, 76.1167°E; altitude about 200 m). The advertisement call of *M. sahyadris* has already been reported from southwestern India: Mangalore and the Western Ghats (KURAMOTO & JOSHY, 2001; KADADEVARU et al., 2002; KURAMOTO et al., 2007; in the two first references as *Limnonectes syhadrensis* according to KURAMOTO et al., 2007). The three descriptions from the literature differ substantially between them, and the calls from the Western Ghats (KADADEVARU et al., 2002) are most similar to the calls of the holotype. One of the most striking features of this call is the first note which is longer than the following ones (including more pulses) and separated from the second one by a longer interval than all the following note intervals of the call. This first longer note has also been reported by KADADEVARU et al. (2002) but the first small pulse of the first note mentioned by these authors has not been observed in our calls. The three previously described calls and the calls described here share a mean dominant frequency of 3.6–3.8 kHz, a short call duration (0.668–1.21 s) and a number of notes per call ranging from 7 to 28.

The calls reported by KURAMOTO & JOSHY (2001) differ in structure from the other calls assigned to this species (KADADEVARU et al., 2002; KURAMOTO et al., 2007; this paper) with respect to the notes which increase in length during the emission of the call and which tend to be divided in pulse groups, ultimately reaching a duration of 300 ms which is about ten times the duration reported here and in KADADEVARU et al. (2002). The numerous and fine spectral bands are not found in the calls described in the other papers. The three frequency bands observed by KADADEVARU et al. (2002) were not found here, nor in KURAMOTO et al. (2007). Although the description of KURAMOTO et al. (2007) was very short, the structure of the call and the few parameters given fit well with the call of the holotype (although the notes are emitted at a faster rate in the call of KURAMOTO et al. (2007), i.e. 15.7 notes/s vs. 9–11 notes/s in the call of the holotype).

A second species of *Minervarya* has recently been described from West Bengal as *M. chilapata* (OHLER et al., 2009) and a short part of its advertisement call described. The structure of the call of this species is basically the same as that of *M. sahyadris*, consisting of a rapid succession of pulsed notes. Three frequency bands are found in *M. chilapata* vs. only one in *M. sahyadris*, lying at about 3.5, 7.0 and 10.5 kHz. Nevertheless the duration of the calls is greater (from 0.9 to 1.9 s) in *M. chilapata* and their calls include more notes (11–27), the duration of the notes is longer (70 ms in average), the notes are emitted at a quicker rate (13.6 notes/s) and there is no interval between two consecutive notes. Furthermore, the first longer note with a greater interval relative to the following characteristic of *M. sahyadris* was not found in *M. chilapata*.

The genus *Fejervarya* is a conservative genus composed of morphologically similar species. The taxonomy of this group is at present not fully resolved and new species will probably be described with increasing population samplings and data set collections (especially of molecular and acoustic data). In this paper, we described the advertisement call of the holotype of *F. pierrei*, *F. teraiensis* and *M. sahyadris*, of paratypes of *F. nepalensis*, and of topotypes of *F. rufescens*. These data should be very useful in species allocation (and taxonomy in general) of newly collected (and recorded) specimens. On the other hand, the advertisement calls attributed to *F. syhadrensis* and *F. multistriata* must be taken with caution as the recorded specimens were caught quite far from their respective type localities. In particular a recent study based on molecular data (KOTAKI et al., 2010) showed that at least some Chinese populations of *Fejervarya* belong actually to *Fejervarya limnocharis*. Further research is needed to confirm their specific allocation.

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Description of the advertisement call of the Moroccan midwife toad (*Alytes maurus* Pasteur & Bons, 1962)

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The Moroccan midwife toad is to date the only species of *Alytes* whose advertisement call remains undescribed. We describe the calls of this species from recordings obtained in a population of the Parc National de Tazzeka (Middle Atlas range) on 21-24 April 2010. We sampled the population calls with two methods: (1) we recorded advertisement calls of focal animals at close range with digital audio equipment (Sound Devices 722 & Sennheiser MKH70 or Olympus LS-10), and some of the recorded individuals were captured after recording and their weight and size was measured; and (2) we also placed an automated timed recording station (Song Meter SM1) in the population, for long-term monitoring of calling activity. Recordings obtained were analyzed using Raven Pro 1.3 software. Males call at dusk and at night during rainy nights. They may call from underground or under rocks or on the surface. Both males carrying eggs and males without them were observed calling. We did not hear female calls. Soil temperature during the focal recordings was between 13 and 18.9°C. The mean snout-vent length and weight of the seven males recorded and captured subsequently were 40.2 mm and 6.91 g (ranges 38-43 mm and 6-8 g). A total of 7 focal recordings of individual males including 202 calls were obtained for analysis. The call is a short tonal burst of sound, like a short whistle. It has a very brief rise time (attack) and a longer fall time, and no additional salient amplitude modulation in the call. The total call duration of the focal recordings was short (mean 97.3 ms, range 77-217 ms). The call has a very simple spectral structure with one emphasized frequency (mean 1324 Hz, range 1218-1406 Hz) and no harmonics nor frequency modulation. Overall, both adult sizes and call parameters are well within the range of variation of those of *Alytes obstetricans*. The calls are shorter in duration than those of *Alytes cisternasii* and *Alytes dickhilleni* at similar temperatures.

INTRODUCTION

The Moroccan midwife toad (*Alytes maurus*) is the least known of all the species of *Alytes*. After the initial debate about its full specific status (ARNTZEN & SZYMURA, 1984, ARNTZEN & GARCÍA-PARÍS, 1995, BONS & GENIEZ, 1996, SALVADOR, 1996; ALTABA, 1997), an effort has been made to obtain information about its basic biology such as distribution, phenology and co-occurrence with other amphibians (LIBIS, 1985; MELLADO & MATEO, 1992; DONAIRE-BARROSO & BOGAERTS, 2003, MATEO et al., 2003, DONAIRE-BARROSO et al., 2006; PLEGUEZUELOS et al., 2010). However, basic ecological information and more specifically behavioral information is still not available for *A. maurus*.

The species of *Alytes* studied to date have a courtship that involves male emitting advertisement calls to attract females (CRESPO, 1981, BUSH, 1993, 1996, 1997, MÁRQUEZ & BOSCH, 1995; BUSH et al , 1996) and vocalizing females approaching the calling male (MÁRQUEZ & VERRELL, 1991; BUSH, 1997). Subsequently, an elaborate amplexus occurs on land (DE L'ISLE, 1873; HÉRON-ROYER, 1886; BOULENGER, 1912; LÓPEZ-JURADO et al., 1979; RODRÍGUEZ-JIMÉNEZ, 1984; MÁRQUEZ & VERRELL, 1991; BUSH, 1993; BUSH & BELL, 1997), where males twine the strings with fertilized eggs around their ankles and keep them on land for several weeks until the tadpoles are fully formed The male then walks to the water and releases the egg masses and the tadpoles hatch.

In this paper we contribute to the knowledge of *A. maurus* by describing its advertisement call, a characteristic that can be of use to detect the presence of this secretive species in unexplored parts of its potential range and that can also be used to establish acoustic monitoring protocols of key populations of this species (e.g., determining frequency ranges of the species advertisement calls for automated recorders, etc)

MATERIAL AND METHODS

Males were recorded in Tazzeka National Park, Taza (Morocco) at night on 21–24 April 2010 (34°08'23 12"N; 04°04'09 09"W, 1283 m a.s.l.) in a rocky area adjacent to permanent springs known as Ain Khabab. Focal recordings of localized males were obtained with a Sound Devices 722 digital recorder with a Sennheiser MKH70 microphone or with an Olympus LS-10 digital recorder on the nights of 21 and 24. Recordings were made at 96 KHz and 24 bits. When the recorded individual could be captured after recording, the air and soil temperature near the recorded individual were subsequently measured to the nearest 0.1°C with a Fluke K 72 thermocouple thermometer. In addition, snout-vent length (SVL) to the nearest millimeter was measured by pressing the male flat (ventrally) against a ruler, and weight was measured with a Pesola spring scale to the nearest 0.5 g. If the males were carrying eggs, the total number of eggs visible from the top plus the number visible from the bottom of the animal was considered an estimate of the clutch size. All animals collected were released in the site to prevent any impact on the population.

In addition to the focal recordings, additional recordings were obtained with an automated recording system (Song Meter SM1, by Wildlife Acoustics, Concord, MA. USA),

which was left in the calling area from 21 to 24 April with a recording protocol of 55 minutes/hour. Automated recordings were made at 44.1 KHz and 16 bits. Air and soil temperature (to the nearest 0.3°C) and relative humidity (to the nearest 2.8 %) were recorded with Hobo Pro-V2 and Hobo Pendant 64 Kb dataloggers adjacent to the automated recording station.

Recordings were analyzed with Raven Pro 1.3 software (Charif et al., 2008) on Apple Macintosh computers in the facilities of Fonoteca Zoológica (Museo Nacional de Ciencias Naturales, Madrid). For spectral analyses, a window size of 4000 samples was used (7.93 Hz precision). Recordings were deposited in the collection of Fonoteca Zoológica (FZ Collection numbers 8994–9000). A sample recording is available on line on the web checklist <www.FonoZoo.com/frogcallsoftheworld>.

Results

Males call at dusk and at night during rainy weather. They may call from underground or under rocks or on the surface. Both males carrying eggs and males without them were observed calling. Only one male was observed (and recorded) carrying eggs (estimate 35 eggs, fig. 1). We did not hear female calls (fig. 2). Only one type of call was recorded or heard during the study period. The advertisement call of *Alytes maurus* is a simple pure tone with a fast rise time and a slow and continuous (not amplitude-modulated) fall time (fig. 3).

Recordings were obtained from seven calling males, which were subsequently captured, measured and weighted (the weight of one male could not be obtained accurately because it was carrying a clutch of eggs). Average calling male SVL was 40.2 mm (SD 1.92, range 38–43, *n* 7); average calling male weight was 6.91 g (SD 1.01, range 6–8, *n* 6). Average air temperature during recording was 16.0°C (range 15.2–17.4°C); average soil temperature was 15.9°C (range 13.1–18.9°C). A total of 202 calls were analyzed, the minimum number of calls analyzed per male was 17 and the average was 28.8.

The values measured for call duration and frequency obtained from the focal recordings are shown in tab. 1. Data on call interval were not calculated because the recordings were made while stimulating males' responses with the emission of vocalisations and whistles by the experimenters. No measurements of Sound Pressure Level were obtained, but the overall call intensity resembled that of the Iberian species.

Calls were recorded with the automated recording system from 4 a.m. to 6 a.m. (GMT) on 23 April (air temperature 8.1–8.3°C, soil temperature 11.1–11.2°C, relative humidity 96 %) and 8 p.m. to 2 a.m. on 23–24 April 2010 (air temperature 9.6–10.8°C, soil temperature 11.6–12.5°C, relative humidity 95.2–95.8 %). In both cases, noise of heavy rainfall was recorded before the calls. A total of 466 male calls were recorded and analyzed (tab. 2), which included calls in 13 discernible frequency categories. Given that male call frequency does not change within calling nights in other species of *Alytes* (Márquez & Bosch, 1995), we estimate that this was a minimum number of calling males in these recordings. In 9 cases, individual calling males could be reasonably identified and inter-call intervals of the (likely) same individual could be measured. Given that these call intervals were not affected by artificial calls produced by the researchers, they are included in tab. 2. Call frequencies were similar to those obtained in the focal recordings. On the other hand, call durations were longer, probably a consequence of lower calling temperatures (see Márquez & Bosch, 1995).

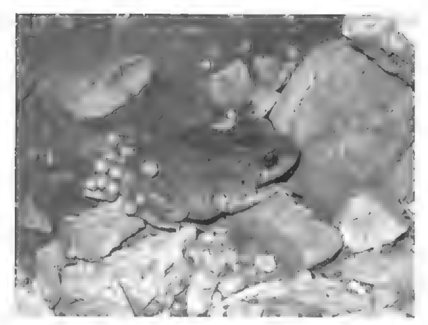


Fig. 1. – Male of *Alytes maurus* with a clutch of eggs. © R. Marquez.



Fig. 2. – Female of *Alytes maurus*. © R. Márquez

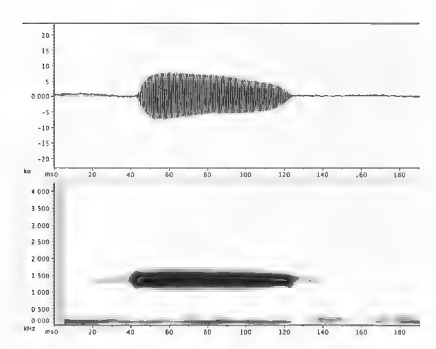


Fig 3. - Oscillogram (top) and audiospectrogram (bottom) of a male advertisement call of *Alytes maurus* (SVL 40 mm, weight 6 g), recorded at a soil temperature of 18 9°C Sound parameters 96 KHz, 24 bits. Spectrogram: FFT 512, Hanning filter.

Discussion

Overall, the advertisement call of *A maurus* closely resembles the calls of the congeneric species from the European continent, being a short pure tone, with no harmonics, no frequency modulation (Heinzmann, 1970; Crespo, 1981; Crespo et al., 1989; Márquez & Bosch, 1995) and substantially lower in frequency than the Balearic insular endemic, *Alytes muletensis* (Bush, 1997) The relationship between call duration and temperature has been shown to differentiate between the continental species and subspecies of *Alytes* (Márquez & Bosch, 1995). If we compare the results obtained with *A maurus*, the measurements from *A maurus* are well within the range of values obtained for *A obstetricans* in Iberia and are shorter in duration than those of *A. cisternasii* and *A. dickhilleni*. The similarity of the call of *A. maurus* with *A. obstetricans* is consistent with the closer phylogenetic affinity between these two species relative to *A. cisternasii*, which occupies an ancestral position in the genus (Martínez-Solano et al., 2004).

The recordings obtained have a low standard deviation and range (less than 200 Hz). This is admittedly a limited sample size, but if the recordings from the automated device obtained over a complete season confirm this trend, this may indicate that the calling individuals are homogeneous in size (because size and call frequency are correlated in other

Table 1. Values of call frequency and call duration from the seven focal recordings made. Mean and standard deviation (SD) are the average of seven individual means. Range is maximum and minimum of all measured calls.

	Call frequency (Hz)	Call duration (ms)
n males	7	7
n calls	202	202
Mean	1324 24	97.34
Average SD (between males)	33 95	0.01
Range	1218.8 1406.2	77.0–217.0

Table 2 – Values of call frequency, call duration and call interval from the recordings obtained by the automated recording system. Mean and standard deviation (SD) are the average of all calls recorded (not grouped by individual). Range is maximum and minimum of all measured calls. Call interval was measured for nine clearly discernible individuals

	Call frequency (Hz)	Call duration (ms)	Call interval (s)
n males	13	13	9
n calls	466	466	243
Mean	1286.16	130.12	8.50
Average SD (between males)	26.89	0.02	3.94
Range	1238 0–1367.2	62.0–190.0	0.4–19.9

species of *Alytes*, see MÁRQUEZ, 1993) This homogeneity of size can be related to the possibility that only some cohorts reach sexual maturity (those produced in more favorable years). Of course this possibility needs to be confirmed by more continuous monitoring of the population.

The population of *A maurus* analyzed was the only one where we could record calling activity in visits to more than seven different sites over five years where the species was previously reported in the Rif and Atlas Mountains of Morocco. In all of them the larvae were scarce or absent, and the sites all appeared to be encroached by human use of water resources. The other species of *Alytes* are known to be vulnerable to pathogens that cause the extinction of populations (BOSCH et al., 2001) and there are important conservation efforts in place in other countries (BOSCH, 2010). We believe that this species deserves a serious effort of monitoring (SLIMANI et al., 2010) and that its conservation status is likely to be more worrisome than currently believed (PLEGUEZUELOS et al., 2010)

Resumen

El sapo partero marroquí es hasta la fecha la única especie del género *Alytes* cuya llamada de apareamiento aún no ha sido descrita. En este artículo se describe la llamada de apareamiento de esta especie a partir de grabaciones obtenidas en una población del Parque Nacional Tazzeka (Atlas Medio, Marruecos) entre el 21 y el 24 de Abril de 2010. Para el muestreo de las vocalizaciones se utilizaron dos métodos: (1) grabación de animales focales a corta distancia con grabadoras digitales (Sound Devices 722 y Sennheiser MKH70 u Olympus LS-10), y (2) grabación de coros con un sistema automático de grabación con temporizador (Song Meter SM1) con el que se realizará el seguimiento a largo plazo de la actividad acústica de la población. Los machos vocalizaron enterrados, bajo piedras o en la superficie, al atardecer y durante la noche de días lluviosos. La temperatura del suelo durante las grabaciones osciló entre 13 y 18.9°C. La media de tamaño corporal y peso de siete machos fue de 40.2 mm y 6.91 g (rangos 38–43 mm y 6–8 g). La llamada del sapo partero marroquí es un tono puro de corta duración, parecido a un corto silbido. Su estructura temporal se caracteriza por tener una fase de ataque muy breve, seguida de una larga caída sin modulaciones de amplitud notables adicionales. La duración total de la llamada fue de media 97.3 ms (rango 77–217 ms). La llamada tiene una estructura espectral simple y una sola frecuencia enfatizada (media 1324 Hz, rango 1218–1406 Hz), careciendo de armónicas y de modulación de frecuencia. En conjunto, tanto el tamaño corporal como los parámetros de la llamada de apareamiento del sapo partero marroquí se encuentran dentro del rango de variación de *A. obstetricans*. Las llamadas son más cortas en duración que las de *A. cisternasii* y *A. dickhilleni* a temperaturas similares.

Résumé

Le crapaud accoucheur du Maroc est la seule espèce du genre *Alytes* dont le chant d'accouplement n'a pas encore été décrit. Dans cet article le chant d'accouplement de cette espèce est décrit à partir d'enregistrements obtenus dans une population du Parc National de Tazzeka (Moyen Atlas, Maroc) entre le 21 et le 24 avril 2010. Deux méthodes ont été utilisées pour obtenir les enregistrements: (1) enregistrements focaux d'animaux localisés à courte distance avec un équipement audio (Sound Devices 722 et Sennheiser MKH70 ou Olympus LS-10), avec capture et notation de poids et taille corporelle après enregistrement, et (2) installation d'un système automatique d'enregistrement temporisé (Song Meter SM1) qui sera utilisé pour suivre la phénologie acoustique de la population. Les enregistrements obtenus ont été analysés avec le logiciel Raven 1.3. Les mâles émettent leurs chants enterrés, cachés sous des pierres ou sur la surface du sol, le soir et la nuit après des journées pluvieuses. La température du sol pendant les enregistrements était de 13–18.9°C. La taille et le poids moyens des sept mâles enregistrés et capturés est de 40,2 mm et 6,91 g (extrêmes 38–43 mm et 6–8 g). Le chant d'accouplement du crapaud accoucheur du Maroc est un ton pur de courte durée, semblable à un court sifflement. Sa structure temporelle ou enveloppe se caractérise par une attaque très brève et une descente plus longue sans avoir d'autres modulations d'amplitude appréciables. La duree moyenne des chants enregistrés est de 97,3 ms (extrêmes 77–217 ms). Le chant a une structure spectrale très simple centrée sur une seule fréquence (moyenne

1324 Hz, extrêmes 1218–1406 Hz), ne présentant ni harmoniques ni modulation de fréquence. En général, aussi bien la taille que les paramètres du chant d'accouplement du crapaud accoucheur du Maroc se trouvent dans le domaine de variation d'*Alytes obstetricans*. Les chants sont plus courts que ceux d'*A. cisternasii* et *A. dickhilleni* à des températures similaires.

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Subgeneric taxonomy and nomenclature of the genus *Hypselotriton* Wolterstorff, 1934 (Amphibia, Urodela)

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Two subgenera were recently recognized in the newt genus *Hypselotriton* Wolterstorff, 1934. The nucleospecies of the subgenus *Pingia* Chang, 1935, described as *Pachytriton granulosus* Chang, 1933, was recently shown not to be a member of this genus but a synonym of *Pachytriton labiatus* (Unterstein, 1930). A new nomen is therefore proposed for this subgenus which includes three species: *Hypselotriton fudingensis* (Wu, Wang, Jiang & Hanken, 2010), *Hypselotriton orientalis* (David, 1875) and *Hypselotriton orphicus* (Risch, 1983).

In a previous paper (DUBOIS & RAFFAËLLI, 2009), we proposed a new taxonomy of the urodelan family SALAMANDRIDAE Goldfuss, 1820, in which we restricted the former genus *Cynops* Tschudi, 1838 to the Japanese species, whereas we placed all Chinese species in the genus *Hypselotriton* Wolterstorff, 1934. Within this latter genus, we recognized two subgenera, corresponding to the two species-groups identified by ZHAO & HU (1984, 1988). The subgeneric hyponymous (nominotypical) nomen *Hypselotriton*, the nucleospecies (type-species) of which is *Molge wolterstorffi* Boulenger, 1905 by original designation, applies to the subgenus including the species *Hypselotriton chenggongensis* (Kou & Xing, 1983), *Hypselotriton cyanurus* (Liu, Hu & Yang, 1962) with its two subspecies, and *Hypselotriton wolterstorffi* (Boulenger, 1905). For the second subgenus, including the species *Hypselotriton orientalis* (David, 1875) and *Hypselotriton orphicus* (Risch, 1983), we used the generic nomen *Pingia* Chang, 1935. This nomen is based on the nucleospecies *Pachytriton granulosus* Chang, 1933, the holotype of which was lost and the taxonomic status of which was long disputed. HOU et al. (2009) had designated a neotype and provided a redescription of this species, which they considered close to, although distinct from, *Hypselotriton orientalis*, so that we recognized three species in the subgenus *Pingia* of *Hypselotriton*.

Shortly after however, NISHIKAWA et al. (2009) provided a detailed study of morphological variation in the species *Pachytriton labiatus* (Unterstein, 1930) and concluded that the

lost holotype and the neotype of *Pachytriton granulosus* belonged in fact in the latter species. The confusion was due to the fact that the juvenile phenotype of *Pachytriton labiatus* is very different from its adult phenotype. The specific nomen *Pachytriton granulosus* then becomes an invalid junior synonym of *Pachytriton labiatus*, and the generic nomen *Pingia* an invalid junior synonym of *Pachytriton*.

This finding leaves the second subgenus of *Hypselotriton* unnamed. Besides the two species *Hypselotriton orientalis* and *Hypselotriton orphicus*, it includes the species *Hypselotriton fudingensis* recently described by Wu et al. (2010). As no genus-series nomen is available for it, we hereby provide a nomen for this subgenus. The entexognosis, the diagnosis and the idiognosis we give to this taxon follow the same plans and should be compared with those of the subgenus *Hypselotriton* in Dubois & Raffaëlli (2009: 45–48).

Subgenus **Cynotriton** nov.

Nucleospecies. – *Triton (Cynops) orientalis* David, 1875, by present designation.

Etymology. – From the Greek *kunos*, genitive of *kuon* ("dog") and generic nomen *Triton* Laurenti, 1768.

Grammatical gender. – Masculine.

Entexognosis. – The most inclusive holophyletic taxon including the species *Hypselotriton orientalis* (David, 1875) and excluding the species *Hypselotriton wolterstorffi* (Boulenger, 1905).

Diagnosis. – (1) Frontal process of premaxillary short. (2) Parotoid glands well developed. (3) Tubercules on external side of hands and feet absent. (4) Skin slightly to very granular. (5) Adaptability in terrarium high. (6) Altitudinal distribution low (0–1000 m).

Idiognosis. – (1) TL 70–90 mm. (2) Habitus stout. Trunk almost quadrangular. Parotoids well developed. Skin slightly to very granular. (3) Dorsal coloration dull, sometimes with bright (red) spots or bands. Ventral coloration very bright, red. (4) Sex dimorphism strong, male small. (5) Mainly aquatic, in lentic habitat. (6) Adaptability in terrarium high, with tolerance of a large gradient of temperature (5–25°C). (7) Eastern China. (8) No tubercules on the external side of hands and feet.

Content. – *Hypselotriton (Cynotriton) fudingensis* (Wu, Wang, Jiang & Hanken, 2010); *Hypselotriton (Cynotriton) orientalis* (David, 1875); *Hypselotriton (Cynotriton) orphicus* (Risch, 1983).

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The authorship and date of the familial nomen Ranidae (Amphibia, Anura)

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The anuran familial nomen *Ranidae* has been credited with several authorships and dates in the recent decades. Some of these changes were due to the rediscovery of older works, and some to modifications in the Rules of the *Code*. The rediscovery of the work of Batsch (1796) brings a new change in this respect, as this nomen was indeed created in this book. This is the first familial nomen of amphibians created, whereas *Testudinidae* Batsch, 1788 is the first familial nomen of reptiles.

The zoological *Code* (Anonymous, 1999) recognizes three "groups of names" or better "nominal-series" (Dubois, 2000): the species-, genus- and family-series. Family-series nomenclature (i.e., nomenclature of taxa at ranks family, superfamily, subfamily, tribe, subtribe and additional intermediate ranks) is regulated by the *Code* but these Rules have regularly been ignored by some zootaxonomists. Some believe that no Principle of Priority applies to these nomina and that the valid nomen of a family-series taxon is fixed by "usage" or "consensus". Others imagine that any such nomen should be credited to the first publication where it was used with its now correct spelling, e.g., *Ranidae* for the family including the genus *Rana* Linnaeus, 1758. Still others think that, to be valid, a family-series nomen must be based on a generic nomen considered valid, and must be changed when the latter becomes invalid (e.g., for being discovered to be a junior synonym). All of this is wrong. The valid nomen of a family-series taxon is the senior one, among all of those potentially available for the taxon (i.e., based on generic nomina now referred to the taxon), except if it is a junior homonym or based on a generic nomen which is itself a junior homonym, and irrespective of the validity of the generic nomen on which it is based (type genus or nucleogenus); and the author and date of any family-series nomen are those of the work where a nomen based on this nucleogenus was coined for a taxon of any rank in the family-series, whatever its ending, under the condition that this nomen was clearly in the nominative plural. The rationale for these Rules was discussed in detail by Myers & Leviton (1962) and Dubois (1984, 1987*b*, 2005*a*, 2011).

Another rather frequent mistake in zoological nomenclature consists in ignoring the Principle of Coordination, which states that all family-series nomina based on the same

generic nomen (e.g., family *RANIDAE*, subfamily *RANINAE*, superfamily *RANOIDEA*, tribe *RANINI*, subtribe *RANINA*, etc.) have the same author and date, that of the first nomen ever proposed for a family-series taxon containing the genus at stake. This Rule is too often ignored, even in works by professional zoologists (e.g., FRÓES, 1957; ALBOUY & CAUSSANEL, 1990; GASC, 1990; MEIN & GINSBURG, 1997) and, at least for some entries, in databases dealing with zoological phylogeny, taxonomy and nomenclature (ANONYMOUS, 2011; BRANDS, 2011).

The familial nomenclatures of rather few zoological groups have been surveyed extensively for the valid nomina of taxa and especially for their valid authorships and dates. In many groups, nomina are used following some kind of consensus, and no authors and dates are given to nomina. Exceptions include the mammals (WILSON & REEDER, 2005), the birds (BOCK, 1994), some mollusks (BOUCHET & ROCROI, 2005, 2010) and crustaceans (NG et al., 2008). In herpetology, the only groups to have been exhaustively and seriously treated are: (1) the recent amphibians, that were covered by DUBOIS (1983, 1984, 1985, 2005*b*), followed, but for some mistakes (see DUBOIS, 1987*a*), by FROST (1985, 2011), (2) the chelonians, treated by BOUR & DUBOIS (1985, 1986), followed, but for some mistakes, by RHODIN et al. (2008, 2009, 2010); (3) some snakes (MCDIARMID et al., 1999). No such comprehensive treatment has been published so far for the other groups of "reptiles", which explains that regularly corrections have to be published concerning the authorships and dates of some family-series nomina (e.g., DUBOIS & BOUR, 2010*b*).

Even in the groups that have been seriously surveyed, it is not rare that earlier uses of family-series nomina are discovered for well-known groups. This is easy to understand. The earliest recognized family-series taxa were based on Linnaean generic nomina made available in the 1758 and 1766–1767 editions of LINNAEUS' *Systema Naturae*. The latter works having been well-known to all zoologists since their publication, any author could coin a family-series nomen based on a generic nomen for a taxon including this well-known genus. Linnaeus did not use the rank family (DUBOIS, 2007) and there is no official starting date for the use of family-series nomina based on generic nomina in zoology. The earliest publication using this system that we know of is that of BATSCH (1788, 1789), where this author coined 17 familial nomina that are duly available under the current Rules of the *Code* and that should be credited to him, not to subsequent authors who used the same nomina (DUBOIS & BOUR, 2010*b*).

In the early days of zoological nomenclature, authorship and date of nomina were not strictly regulated and were often ignored because of a widespread "mihilism" (BRUUN, 1950, DUBOIS, 2008), i.e., a propensity of some authors to claim authorship for some nomina although they had not coined them but just "redefined" them. Now we have strict Rules, and nomina are created once and for all and cannot be "redefined", because of the existence of what has been called the *Principle of Nomenclatural Foundation* (DUBOIS, 2011). In the three nominal-series covered by the *Code*, nomina are "defined" only through their onomatophore, not by any intensional or extensional definition (DUBOIS, 2011). Therefore, if two different authors create independently (i.e., in the ignorance of the other's work) two family-series based on the same generic nomen, the latter is the onomatophore of both and they are strict objective synonyms or *isonyms* (DUBOIS, 2000). It could be argued that in such a case the two nomina are indeed independent homonymous and isonymous nomina, but this would have no practical consequence on the valid author and date of the family-series nomen, which would in all cases remain that of the first published one. Practically, it would be very difficult, if not

impossible in some cases, to ascertain whether the second author had used the nomen proposed in an earlier work by the first author, or whether he/she thought he/she had indeed coined a "new" nomen, because most authors of that time (and in fact still nowadays even in taxonomic revisions, faunistic lists, catalogues of specimens or taxa, etc.) just mentioned family-series nomina but not their authors and dates. It is therefore much simpler, and without any nomenclatural consequence, to consider that any family-series nomen based on a given generic nomen has been coined only once, in the first publication where it appeared, and that any subsequent appearance of this nomen, either identical or modified in its ending (e.g., -*INAE* instead of -*IDAE*), is not a new nomen but respectively a chresonym or an *aponym* of the *protonym* used in the first publication (for the definitions of these terms, see DUBOIS, 2000). This guideline was used in all our previous works (e.g., DUBOIS, 1984, DUBOIS & BOUR, 2010*b*) and we use it here.

The case of the family *RANIDAE* is a very enlightening one. Although this nomen, under various spellings, has been used continuously by all authors since 1825 for a family including the genus *Rana* Linnaeus, 1758, its authorship and date have changed regularly, in part because of incomplete bibliographic surveys by authors, and in part because inappropriate changes implemented in the *Code* in 1985 (for a discussion of this point, see DUBOIS, 1987*b*, 2011). The authorship and date traditionally credited to this nomen (e.g., DOWLING & DUELLMAN, 1974 1978) was BONAPARTE (1831), because this author was thought (in error) to have been the first one to use the correct spelling *RANIDAE* for this family. DUBOIS (1984) pointed out that the spelling *RANIDAE* had been used already by BOIE (1828), but, as established by DUBOIS (1981), the nomen had in fact been created by GRAY (1825) under the spelling *RANADAE*. However, an earlier nomen, *RANARIDIA* Rafinesque-Schmaltz, 1814, based on *Ranaria* Rafinesque-Schmaltz, 1814, an invalid neonym (nomen novum) for *Rana* Linnaeus, 1758, was also available for this family. According to the *Code* then in force (ANONYMOUS, 1964), the family had to be named *RANIDAE* Gray, 1825 (1814) and its eponymous taxa (*RANOIDEA*, *RANINAE*, *RANINI*) had to be credited with the same authorship and date (DUBOIS, 1981, 1984). The subsequent discovery (DUBOIS, 1985) that GOLDFUSS (1820) had already recognized a family *RANAE* should have led to a new authorship and date for the family, as *RANIDAE* Goldfuss, 1820 (1814), but the third edition of the *Code* (ANONYMOUS, 1985) modified the Rules in force in such cases, so that the valid nomen became *RANIDAE* Rafinesque-Schmaltz, 1814 (for details, see DUBOIS, 1985) Here we report on a new discovery that again modifies the authorship and date of this familial nomen.

The work of BATSCH (1788) has never been completely forgotten (see e.g. STEJNEGER, 1907), but it was not until the resurrection by BOUR & DUBOIS (1985) of the family-series nomen *TESTUDINES* Batsch, 1788 as the valid nomen for the family *TESTUDINIDAE* that it was used as the first identified source of available family-series nomina in zoology. DUBOIS & BOUR (2010*b*) confirmed this fact and pointed to 16 other available and valid familial nomina over the whole of zoology coined by BATSCH (1788, 1789) that had been ignored until then

BATSCH (1788, 1789) was not consistent in the derivation of his familial nomina. These nomina belong in three categories (DUBOIS & BOUR, 2010*b*). Some were clearly based on an available generic nomen recognized by Batsch as designating a valid genus these *rhizonyms* (DUBOIS, 2006*b*) are correctly formed and they are available nomina under the *Code* or *hoplonyms* (DUBOIS, 2000). Others were not based on generic nomina: such *arhizonyms*

(DUBOIS, 2006*a*) are incorrectly formed and are unavailable nomina under the *Code* or *anoplonyms* (DUBOIS, 2000). Finally, others are based on available generic nomina, but the latter were not used by Batsch as valid in the new family-series taxon; these nomina can be called *cenorhizonyms* from the Greek κενός (*kenos*), "empty, vain", ῥίζα (*rhiza*), "root" and ὄνομα (*onoma*), "name". The status of such nomina is addressed in Article 11.7.1.1 of the *Code*, which states that, for a new family-series nomen to be available it must be based on a generic nomen "*then used as valid in the new family-group taxon*". The meaning of "*then*" in this Article is questionable, but we here follow the interpretation that we presented elsewhere (DUBOIS & BOUR, 2010*b*), according to which the generic nomen must be used as valid *in the new family-group taxon as recognized in the work where its nomen is created*. According to this interpretation, cenorhizonyms are also anoplonyms under the *Code*.

The 17 family-series rhizonyms in BATSCH (1788, 1789) are doubtless nomenclaturally available. They have priority over all other nomina proposed later on for the same taxa and should replace them. As these changes in authorships and dates do not imply any change in the nomina of the family themselves, they can and must be implemented without delay in all the zoological groups concerned (DUBOIS & BOUR, 2010*b*).

Another work of BATSCH (1796) seems to be still rarer than his first two books. It was mentioned in catalogues in the 19th century, but forgotten in the 20th. It was "rediscovered" in the 21th century (CHANDRA, 2005, RHODIN et al., 2008) by authors who mentioned it but did not discuss its nomenclatural implications in zoology. This work was recently digitalized and made available to all interested zoologists by "Die Bayerische Staatsbibliothek München" (<http://reader.digitale-sammlungen.de/resolve/display/bsb10074788.html>), so we had access to it. It so happens that this work contains two new available familial nomina, not mentioned in Batsch's first work.

BATSCH (1796: 73) recognized a family *OVINA*. This nomen, based on *Ovis* Linnaeus, 1758, has priority over *BOVIDAE* Gray, 1821 for the family and its subordinated taxa including the genus *Ovis*. As the nomen *BOVIDAE* has had a widespread use in zoology, it should be validated against *OVINA*: we will address this question in a distinct paper.

BATSCH (1796: 179) also recognized a family *RANINA*, based on *Rana* Linnaeus, 1758. The situation is clearer in this case. In 1788, Batsch had recognized a family "*BATRACHI*", with the four frog genera *Bufo* Laurenti, 1768, *Hyla* Laurenti, 1768, *Pipa* Laurenti, 1768 and *Rana* Linnaeus, 1758. Although a generic nomen *Batrachus* Schaeffer, 1760 was available at that time (DUBOIS & BOUR, 2010*a*), it was a genus of "fishes" and it cannot be at stake here: the first frog generic nomen *Batrachus* was created by RAFINESQUE-SCHMALTZ (1814) and cannot be the basis for the stem of "*BATRACHI*" Batsch, 1788. The latter is therefore an arhizonym and anoplonym (DUBOIS & BOUR, 2010*b*). In contrast, the nomen *RANINA*, which BATSCH (1796) substituted for his nomen "*BATRACHI*", being based on the generic nomen *Rana* Linnaeus, 1758 that he recognized as valid, is a rhizonym and hoplonym. It has priority over the nomen *RANARIDIA* Rafinesque-Schmaltz, 1814. This change is a very fortunate one, because it allows to credit again the family-series nomen *RANIDAE* (widely used, and at many different ranks) to a publication where it was indeed based on the generic nomen *Rana* Linnaeus, 1758 — and not on a neonym of the generic nomen nowadays considered valid for the taxon (for details and discussion, see DUBOIS 1987*b*, 2010).

Therefore *Ranidae* Batsch, 1796 becomes the valid nomen of the family and of its eponymous taxa (*Ranoidea*, *Raninae*, *Ranini*, *Ranina*) if recognized as valid taxa.

In herpetology, Batsch (1788) recognized four families in his classis **Amphibia**. The nomen of one of them (*Testudines* Batsch, 1788, for the single genus *Testudo* Linnaeus, 1758) was a rhizonym (based on the root of a generic nomen considered valid) and a hoplonym (available) and should now be used as the valid nomen of this family, as *Testudinidae* Batsch, 1788. The other three ("*Batrachi*" Batsch, 1788; "*Lacertae*" Batsch, 1788; "*Serpentes*" Batsch, 1788) are cenorhizonyms (based on the root of a generic nomen considered invalid) and anoplonyms (unavailable), and are therefore without nomenclatural existence.

Eight years later, Batsch (1796) kept the same taxonomy for his classis Amphibia but modified the nomenclature of the families. He changed his family nomen *Testudines* into *Testudineae*: this is not a new nomen but just an aponym (derived form of nomen) of the protonym (original form of nomen) *Testudines*, which therefore keeps the same authorship and date, i.e., Batsch, 1788. He also modified his family nomina "*Lacertae*" and "*Serpentes*" into respectively "*Lacertina*" and "*Serpentina*": these are also aponyms, but as they remain cenorhizonyms they remain anoplonyms and have therefore no nomenclatural existence. Finally, he replaced his nomen "*Batrachi*" by the new nomen *Ranina*, which is a rhizonym and hoplonym, and becomes the valid nomen of the family.

Ranidae Batsch, 1796 is the first familial nomen of amphibians ever created, whereas *Testudinidae* Batsch, 1788 is the first familial nomen of reptiles.

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